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SUSTAINABLE DEVELOPMENT OF SMART CITIES IN THE CONTEXT OF THE IMPLEMENTATION OF THE TIRE RECYCLING PROGRAM*

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Abstract. At the present moment of society's development, the concept of Smart City development is attracting more and more attention. According to this approach, urban space should be implemented from the position of improving the quality of life of citizens. As part of the development of a smart city, rational and economical use of resources is assumed. This attitude to resources allows not only to save resources but also to improve the quality of life of the population, particularly by improving the environmental situation in the regions. In the world practice of developing cities, the recycling processes are becoming more and more relevant. On the one hand, this saves material and energy resources. On the other hand, these measures help to improve the quality of the environment in the regions. Recently, two concepts have become a trend in the development of urban economy in world practice. One of them is the concept of a smart city, the other is the concept of sustainable urban development. Despite a number of differences, both approaches to city management imply a focus on environmental friendliness. Implementing strategies of development of Russian cities in the framework of the concept of sustainable development and within the concept of smart cities aims to improve the environmental situation in the country. Therefore, the aim of the research was to improve the environmental potential of Russian regions through the use of modern Russian and foreign research, in particular through the tire recycling program. For Russia, one of the key environmental problems is the problem of recycling car tires. Despite the emergence of new eco-friendly ways of recycling tire waste, it is becoming more acute every year. This is understandable, because the number of cars increases every year. Currently, decommissioned tires are a source of environmental pollution in most of the Russian regions. However, this source of pollution is a long-term source. This is due to the fact that worn tires are practically not susceptible to natural decomposition, and, as a result, require increasing space for their storage and disposal. The article provides an analysis of the dynamics and prospects of car tire recycling in the framework of the concept of sustainable development of smart cities. A comparative analysis of the state of this issue in Russian and foreign practice is presented. In addition, according to statistic analysis, the article provides a forecast analysis of the increase in waste in the form of tires and an analysis of the regulatory framework governing the recycling process.

Keywords: smart city; sustainable city; circular economy; waste management; economic effect; resource-saving technologies; tire recycling

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1. Introduction

According to the McKinsey Agency, there are about 200 smart cities in the world today. The most developed in this area include London, Singapore, Seoul, New York, Helsinki, Montreal, Boston, Melbourne, Barcelona, and Shanghai. At the same time, there are practically no Russian regions in the international smart city rankings, with the exception of Moscow, St. Petersburg, and Novosibirsk, which are also far from leading positions. At the same time, by the end of 2025, it is planned that there will be about 600 smart cities in the world (Urban world: Mapping the economic power of cities, 2011). This means that the number of smart cities in the world should increase by 3 times. This makes it necessary to develop approaches to creating and managing Smart City development as soon as possible (Machado, 2017).

The Ministry of construction of the Russian Federation has adopted a pilot project to create a Smart City on the basis of Russian cities. In addition, 8 Russian cities such as Krasnodar, Innopolis, Tolyatti, Novorossiysk, Sarov, Sochi, Voronezh and Magas are part of the International Smart Sustainable City Club (ISSCC).

However, today there is no clear approach to the concept of "Smart City". But having studied the world's leading practices, we agree that a smart city is a new approach to the implementation of urban space based on the use of digital technologies, based on the principles of:

- ✓ the open space;
- ✓ management transparency;
- ✓ involvement of citizens in the management process;
- ✓ improving the quality of life (Saptadi *et al.*, 2019).

Smart city combines several elements such as:

- ✓ smart environment (renewable energy, resource saving, etc);
- ✓ smart mobility (transport networks, smart parking, wifi coverage, etc.);
- ✓ smart lifestyle (comfortable structure of the city, health saving technologies, etc.);
- ✓ smart people (educated, able to participate in urban processes using ICT).
- ✓ smart economy (Saptadi *et al.*, 2019).

Thus, a "smart city" is a city that strives to ensure sustainable development in all plans (economic, social, political), as well as a high quality and standard of living with reasonable management of natural resources and the environment, while using digital and information technologies, data collection, processing and analysis technologies, as well as technical solutions and appropriate infrastructure (Novikov *et al.*, 2019; Rostova *et al.*, 2019).

Thus, one of the important elements of forming a smart city system is the rational use of resources, which allows to save resources, as well as improve the quality of life, including by improving the environmental situation in the regions (Sienkiewicz *et al.*, 2017).

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In the world practice of developing smart cities, recycling processes are becoming more and more popular. On the one hand, this saves material and energy resources. On the other hand, this makes it possible to improve the quality of the environment in the regions (Ahvenniemi *et al.*, 2017).

One of the key environmental problems in Russia is the problem of recycling car tires. It is becoming more acute despite the emergence of new eco-friendly ways to dispose of them. This is due to an increase in the number of cars.

However, similar problems are not unique to Russian cities. In this regard, it becomes very relevant to analyze the current state, as well as to identify the prospects for the development of municipalities from the perspective of sustainable development of smart cities.

Thus, the goal of the research is to increase the environmental potential of Russian cities within the framework of the implementation of the concept of sustainable development and the concept of smart cities, in particular through adequate utilization of tire waste.

The following problems should be resolved to achieve the goal:

1. Analysis of international urban development practices in accordance with the concept of sustainable development and the concept of a smart city from the point of improving the environmental component, in particular through adequate utilization of tire waste.
2. Identification of trends in tire waste disposal in international and Russian practice with a focus on sustainable development of territories.
3. Detection of the potential for the development of Russian cities in the framework of the concept of sustainable development and the concept of smart cities based on the analysis

2. Theoretical Framework and Literature Review

Countries are increasingly faced with the need to improve the efficiency and competitiveness of their economies. This is due to hyper-competition in the global market. However, for further development of production, it is necessary to increase the consumption of resources. This causes a huge increase in production waste. This becomes critical for the future existence of the society.

A similar problem was raised by Ahvenniemi *et al.* (2017). They note that, as expected, modern cities place much more emphasis on modern technology and "smartness" compared to urban sustainability concepts. At the same time, they emphasize that the environmental component is also important in the development of the smart city concept. In addition, they note that it is extremely important that when assessing the effectiveness of a smart city, not only indicators of the effectiveness of smart solutions are used, but also impact indicators that measure the contribution to the achievement of final goals, such as environmental, economic or social sustainability.

The need for a symbiosis of the concepts of "smart" and "sustainable" urban development is considered by Nižetić *et al.* (2019). In their opinion, it is intellectual technologies that will allow society to have a sustainable future. The main goal of modern society is sustainability and reasonable use of limited and valuable resources. However, as the authors note, there are completely different approaches and standards to sustainable development in society, which depend on geographical, temporal and cultural aspects.

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Analysis of the current state of cities in the framework of two concepts "smart city" and "sustainable city" is considered in the study of Shmelev and Shmeleva (2018). This research analyzes more than 90 cities around the world. The results of the study showed that San Francisco leads in economic and environmental priorities, while Stockholm leads in social and smart urban priorities. Seoul is performing well across the entire spectrum of indicators.

Zhang et al. (2019), looking at the example of the Chinese economy, note that, of course, it is necessary to create a new type of management thinking aimed at the transition to a "circular economy with zero waste" (Zhang *et al.*, 2019). They note that this is particularly relevant for China. At the same time, the study says that this problem is extremely complex, because it involves many stakeholders. The research highlights twelve important barriers to intelligent waste management in China. Among the strongest barriers, the authors highlight "the lack of regulatory pressure, the lack of environmental education and culture of environmental protection, as well as the lack of market pressure and requirements." Also, among the problems mentioned are smart waste management, the lack of a legal framework for mandatory waste disposal, and economic and financial problems related to the lack of funding.

Similar barriers to spreading the concepts of a "smart" and simultaneously "sustainable" city are noted in the work of Zhang et al. (Zhang *et al.*, 2018).

Thus, it is clear that the creation of smart solutions for the organization of urban economy does not always provide for the environmental sustainability of these solutions.

For example, increasing transport accessibility as part of the development of the smart city concept, and the influx of people to these cities lead to an increase in the number of cars. This creates a problem associated with the disposal of failed cars and their parts.

The problem of increasing waste in the form of automobile tires has affected all developed countries. At present, this problem is receiving a lot of attention, both from the scientific community and from Governments.

At the same time, tire waste can be a good source of raw materials (Fagundes, 2017). This will not only solve environmental problems but also save financial resources.

So in their research Sienkiewicz et al. (2017) came to a number of conclusions based on a comprehensive review of changes in policies and approaches to tire recycling. First, the recycling and restoration of tires is a serious environmental problem due to their very complex structure and composition. Secondly, the governments of many countries are interested in developing new technologies for environmentally friendly recycling of tires. They note that there has been significant progress in sustainable waste management recently. This new approach is already being applied in the US, China, Japan and the EU. Also, the authors' note that used tires should not be considered as a pollutant, but as a source of materials.

Sienkiewicz et al. (2017) remark that already known technologies can be used for recycling tire waste. Thus, these measures do not require significant investment. But at the same time, they allow for "sustainable and clean recycling". It's good for both concepts - "smart city" and "sustainable urban development".

Gupta et al. also focused on waste recycling from the perspective of economic development (Gupta et al., 2019).

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In their research Pereira et al. (Pereira *et al.*, 2018), based on data from Brazil, tried to deduce the correlation between the number of tires coming for recycling and external factors. This research assumes forecasting the percentage of utilization under different conditions.

A large group of scientific papers is devoted to the re-use of waste. In particular, considering tire waste as raw materials. The work notes that on the one hand, proper recycling of tire waste will reduce the level of environmental pollution, and on the other hand, will allow you to get an additional economic effect.

Thus, in their article, Arulrajaha et al. (2019) note that used tires are indeed a big problem for sustainable urban development. At the same time, they suggest using this raw material as the basis for road pavement (sidewalks). They say that the increased strength of this type of coating. This approach also fits well into both the concepts of "smart city" and "sustainable urban development".

Similar conclusions were reached by Wang et al. (2019). The rapid growth in the number of cars in China has generated an increase in tire waste. At the same time, it is noted that currently 62.8% of tire waste is not processed in China. As a solution to the problem with recycling, the authors proposed adding rubber crumbs to the asphalt concrete pavement. They note that this will "contribute to the sustainable management of worn tires." And the use of crumb for asphalt production will be on the one hand "an effective method of balancing the contradictions between the supply and demand of rubber crumb", and on the other hand will significantly reduce carbon emissions into the atmosphere. In addition, the authors note that this data will reduce the dependence on non-renewable resources in the production of asphalt.

Thus, urban management in the context of the implementation of two concepts at once: the concept of "Smart city" and the concept of "Sustainable urban development", of course, should become a driver of development.

However, there are factors that negatively affect the implementation of these concepts.

Ghosh et al. (2019) note that there are already many promising technologies for processing various types of waste. These technologies fully correspond to the concept of smart cities development. However, these methods are either not used at all, or are not fully used. This is particularly true in developing countries.

The same opinion is present in the work of M. Maryono and I. Hasmantika (2019). They believe that a number of technologies developed in advanced countries still cannot be applied in "cities of developing countries" because of their complexity. In addition, the authors note that the lack of environmental education of the population, as well as the lack of regulatory documents on waste disposal and recycling, greatly affects the development of cities within the framework of the concept of a smart and sustainable city.

Dong and Fujita (2015) note that it is difficult for society to balance economic growth with a low level of environmental pollution, in particular waste from burning tires. They note that in the framework of the development of society it is necessary to rely on the practice of Japanese cities with low carbon emissions. It focuses on two national initiatives: the eco-city project and the smart city project. The authors believe that applying this practice to Chinese cities will dramatically reduce carbon emissions into the atmosphere.

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3. Materials and Methods

3.1. The importance of tire recycling in the in the Russian Federation

Currently, decommissioned tires are a source of environmental pollution in most of the Russian regions. However, this source of pollution is a long-term source. This is due to the fact that worn tires are almost not susceptible to natural decomposition. As a result, they require more and more space for their storage and disposal.

Today, there are certain strategies for dealing with worn tires. The most common ones are:

- ✓ reuse;
- ✓ export;
- ✓ recovery;
- ✓ mechanical processing;
- ✓ thermal processing;
- ✓ burial.

However, the latter two approaches are not acceptable within the framework of the concept of sustainable regional development, as well as the concept of Smart City, which implies significant attention to environmental issues.

According to statistics, only about 20% of used tires are recycled in Russian regions (Rostova *et al.*, 2019).

At the same time, worn tires are an excellent source of recyclable materials. They contain rubber, carbon black (almost pure carbon), metal and synthetic cord. In this case, the rubber is 70% of the weight of the worn tire. (Wang *et al.*, 2020).

If incineration is used as a measure to dispose of tires, a large amount of toxic waste is released into the atmosphere. These emissions are several times higher than when burning coal (table 1), which also completely contradicts the concept of "smart cities" development:

Table 1. Emissions of pollutants into the atmosphere

Pollutant	Coal combustion	Burning of worn tires
Sulfur, %	2.00	1.3–2.2
Ash, %	11.30	12.5–18.6
Chlorine, %	0.14	0.20
Zinc, particles per million air particles	27.20	9300–20500
Chrome, particles per million air particles	20.50	97.0
Nickel, particles per million air particles	16.90	77.0
Plumbum, particles per million air particles	8.30	60–760
Cadmium, particles per million air particles	0.91	5–10

Source: compiled by the authors based on (Rostova *et al.*, 2019)

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Thus, the problem of recycling worn-out car tires is a common problem that faces all industrialized countries. The solution to this problem is of great environmental and economic importance (table 2).

Table 2. Value of tire recycling in the context of the Smart City concept

Value	Essence
Environmental	<ul style="list-style-type: none"> ✓ Tires that are located for a long time in organized landfills or on other territories are a source of environmental pollution. ✓ They have a high degree of fire hazard. ✓ In the case of burning tires, the process is accompanied by emissions (about 150 different toxic compounds), which are dangerous to human health and the environment.
Economic	<ul style="list-style-type: none"> ✓ Worn tires are a valuable resource. At the same time, tire recycling becomes a priority task in conditions of resource constraints. Recycled raw materials can be reused in various areas of production. ✓ The elimination of tire dumps allows for the release of significant land areas for their more rational use.

Source: compiled by the authors

In this regard, the issue of improving the quality of life, as well as issues of resource-saving technologies, which have become relevant in the context of the irreplaceability of material resources, become a priority in the development of the concept of smart cities.

3.2. Analysis of foreign experience in tire waste disposal

The number of cars on the planet is growing rapidly (figure 1), and the dynamics is exponential. Accordingly, the amount of waste generated increases in proportion to the increase in the number of vehicles. Over the past 20 years, the number of worn tires has increased by about 2 times (Novikov *et al.*, 2019).

Figure 1 confirms that the challenge of recycling used tires is currently a much bigger problem for Russia than for developed foreign countries. Over the past 20 years, the number of passenger cars in Russia has increased by more than 3 times. Consequently, the number of tires in need of recycling has increased proportionally.

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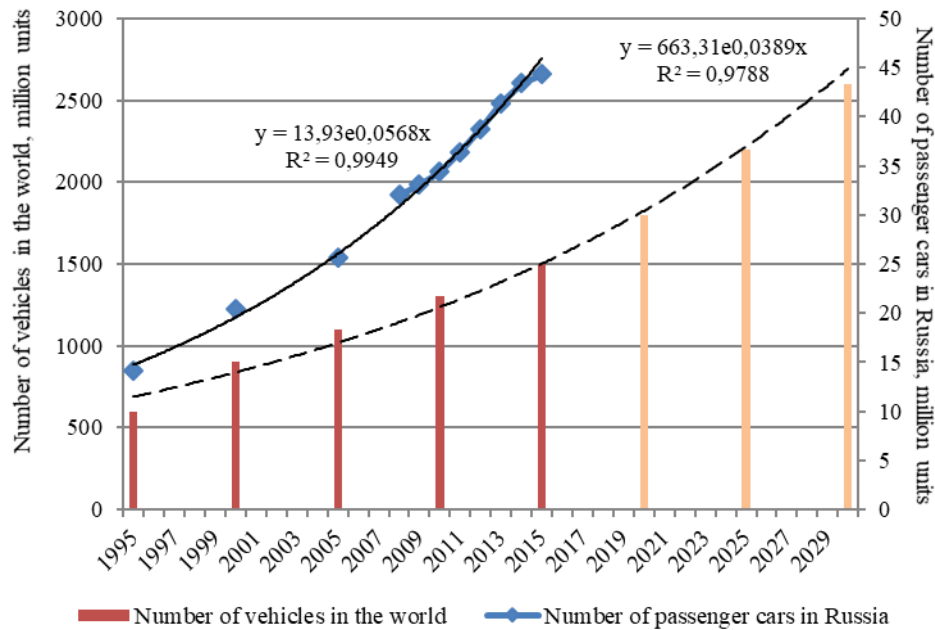


Fig 1. Dynamics of the number of vehicles

Source: compiled by the authors based on (Novikov *et al.*, 2019)

At the same time, the global amount of tire waste according to various estimates ranges from 60 to 80 million tons. The annual increase is approximately 10 million tons of tires (Novikov *et al.*, 2019). Thus, the annual growth rate exceeds 10%. Only in the US, 4.3–4.5 million tons of worn tires are produced per year, in Europe-up to 3 million tons, in Japan – about 1 million tons (Novikov *et al.*, 2019).

However, this is not the case in all countries. For example, in developed countries: Japan, Germany, and the Scandinavian countries, the recycling rate of tires is approaching 100%. If we talk about Europe as a whole, we have determined the average utilization rate, which exceeded 76%, based on table 3 (table 3).

Table 3. Analysis of tire recycling in Europe

Country	Number of tires, million tons	Tire recycling, million tons			Tire recycling, %	Rank
		Construction	Utilization	Energy		
Estonia	15		15		100.00	1
Hungary	36		27	9	100.00	1
Latvian	9		4	5	100.00	1
Romania	34		3	31	100.00	1
Slovenia	15		8	7	100.00	1

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Sweden	80	20	19	40	98.75	2
Finland	51	34	8	8	98.04	3
Denmark	39		38		97.44	4
Austria	63		24	36	95.24	5
Poland	169		35	123	93.49	6
Greece	34	1	15	14	88.24	7
Slovakia	27		17	6	85.19	8
Italy	421	2	118	234	84.09	9
Norway	39	2	11	18	79.49	10
Czech	57		17	28	78.95	11
Portugal	84	1	38	27	78.57	12
Lithuania	23		9	9	78.26	13
Spain	296	6	98	124	77.03	14
France	457	33	92	227	77.02	15
Great Britain	527	34	174	187	74.95	16
Belgium	76		45	10	72.37	17
Germany	582		201	212	70.96	18
Irish	30		12	9	70.00	19
Netherlands	91	1	50	11	68.13	20
Bulgaria	29		15	4	65.52	21
Turkey	260		98	38	52.31	22
Cyprus	5				0	23
Malta	1				0	23
Switzerland	40				0	23
TOTAL	3 590	134	1 191	1 417	76.38	

Source: compiled by the authors based on (Annual tire recycling report for Europe, 2017)

Analyzing the table data, it can be concluded that in countries such as Cyprus, Malta, and Switzerland there is no recycling production. First of all, this is due to the fact that these States are small and all tires that have failed are exported.

If we analyze the most popular tire recycling strategies used in Europe, we can note that only about 1% of the volume is disposed of (figure 2) (Kolganova, 2018). The most popular type of processing is the production of rubber crumb, which is later used for economic purposes, for example, for the manufacture of road surfaces.

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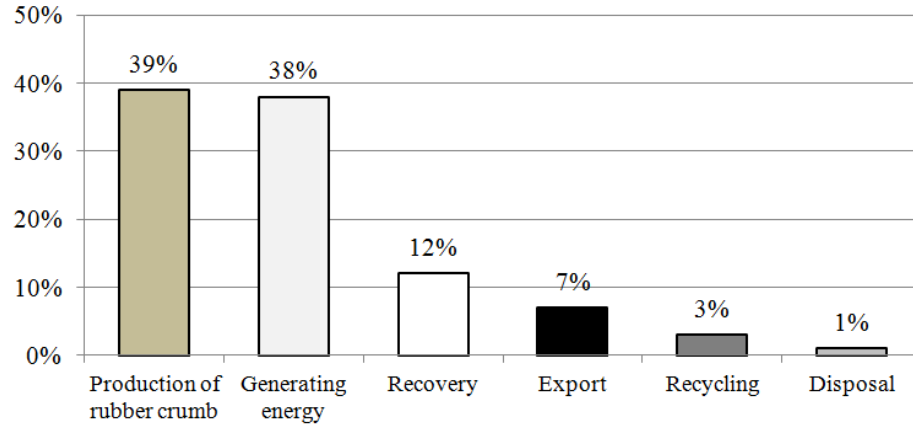


Fig. 2. Strategies for managing worn tires in Europe
Source: compiled by the authors based on (Kolganova, 2018)

To sum up, it should be noted that thermal and mechanical processing are the most popular in Europe (figure 2). In addition, for most developed foreign countries, old tires are a source of valuable raw materials that are usually processed. This is fixed not only in normative documents, but primarily in the minds of the population. If we talk about the legal regulation of the process of recycling tire waste, it should be noted that in Europe, the treatment of worn tires is regulated by three main regulatory documents. By analyzing the international experience of waste tires, it becomes clear that the creation of an effective system of collection and further processing components, the active position of the state in this matter: regulation of the issue at the legislative level, the provision of subsidies to organizations involved in recycling, creating conditions to increase the attractiveness of the sector for its participants (Zvonov *et al.*, 2000). If we talk about the financial side of the issue of recycling of worn tires, there are currently three models for financing the disposal of worn tires in the European Union (table 4).

Table 4. Systems for financing the recycling of used tires in Europe

System	Principle of functioning	Countries that use this system
Tax System	As part of this system, the state introduces tax payments, which serve as the main source of subsidies for processing industries.	Hungary, Denmark, Slovakia, Latvia
Producer Responsibility	Responsibility for disposal lies with the suppliers. The source of financing for recycling processes is a fund to which tire manufacturers transfer money depending on the amount of revenue, including these costs in the cost of new tires.	Sweden, Norway, Finland, Portugal, Poland, France. The transition to this model is expected in Great Britain, Spain, Hungarians.
Free Market System	Each tire owner independently selects counterparty for tire recycling. This model works effectively only in countries with a high standard of living and a level of civil responsibility of the population.	Germany, Italy

Source: compiled by the authors based on (Zvonov *et al.*, 2000)

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Today in Europe there are about 40 different companies involved in the recycling of old tires. The main goal of these companies is to collect and process tires in a quantity that would be comparable to the production of new tires. The principle that applies in Europe is "one new tire is sold – one old tire is recycled".

Figure 3 shows the dynamics of tire recycling in European countries. The figure shows that the trend of tire recycling is linear and increasing.

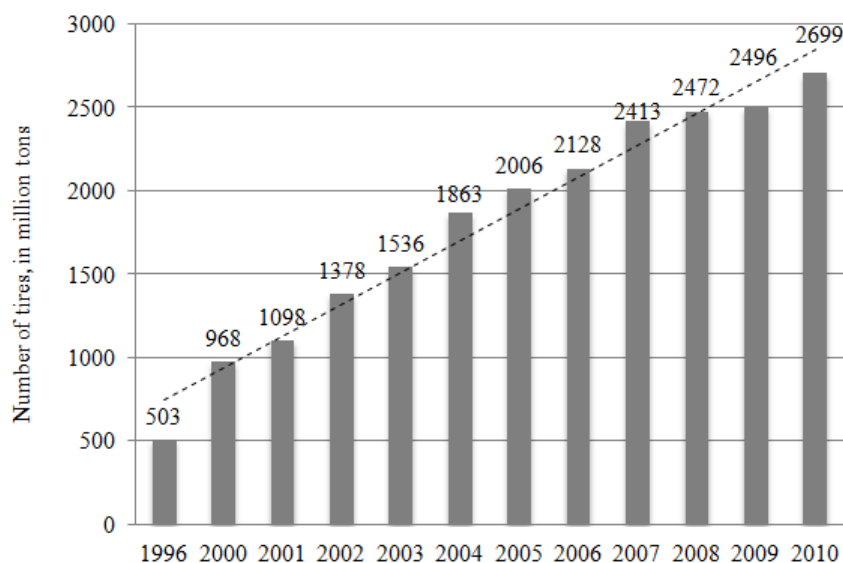


Fig. 3. Dynamics of car tire recycling in Europe
Source: compiled by the authors based on (Rostova *et al.*, 2019)

Considering the issues of tire recycling in the United States, it should be noted that almost all States have adopted special laws and programs that regulate the management of tire waste. It is clear that each of the States has its own nuances regarding tire recycling. However, several similar principles can be identified in the analysis:

- ✓ financial support for tire recycling is provided by taxes and fees. For example, the amount of payment for the recycling of tires varies from 0.5 to 2\$ for passenger car tires, and from 3 to 5\$ for a truck;
- ✓ tire recycling activities (assembly and processing plants) are subject to licensing;
- ✓ participants in the recycling process: sorters and processors are provided with financial guarantees (Kolganova, Gubanova, 2018).

The Japanese tire recycling system is more than 18 years old. Currently, the country of the rising sun has a "law on waste recycling", according to which every citizen is obliged to personally deliver worn-out tires to the places where they are collected. At the same time, the recycling fee is 300 yen, which in terms of the Russian ruble is about 174 rubles. In parallel, in Japan, there is a law that imposes responsibility for the collection and disposal of tires on the manufacturers of new tires themselves. At the legislative level in Japan, it is stipulated that the reuse of resources obtained during recycling should be at least 70%.

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Analyzing the experience of tire recycling in Europe, Japan and the United States, we can draw the following conclusion: regulation of this issue by the state and responsibility, as well as the proactive position of citizens in relation to waste disposal, contribute to the development and effective operation of the industry of recycling old tires. Adopting the experience of the above-mentioned countries, you can achieve both economic benefits from organizing and conducting business activities in the field of recycling broken tires, and improve the environmental situation by recycling unnecessary waste.

3.2. Analysis of Russian experience in tire recycling

Currently, two concepts of urban development are applied in the Russian Federation: the concept of sustainable development, and the concept of smart city. One of the key aspects of these concepts is to improve the environmental situation in the country. Particularly, one of the most important environmental problems is environmental pollution due to the constant increase in tire waste. Therefore, recycling tires is a priority task in the sustainable development of the concept of smart cities in the Russian Federation. It not only reduces the consumption of material resources, but also is a priority in the development of environmental protection and environmental measures. Worn-out tires are subject to the Federal law of the Russian Federation of 1998 No. 89-FZ "on production and consumption waste". It is a waste of the fourth class of danger.

At the same time, the percentage of tire recycling in Russia is much lower than in European countries (Chistov, Pavlov, 2014). It is currently around 5% to 20% according to various estimates (Stets, Chaykun, 2013), while in Europe this figure is approaching 80%. According to "Shinoecology" data (Kolganova, 2018), about 1 million tons of worn-out tires are produced annually in Russia, the change in the dynamics of this indicator is shown in table 5.

Table 5. Estimation of the total number of tires for recycling in the Russian Federation

	The volume of waste tires in Russia, thousand tons	Utilization	
		thousand tons	%
2016	800.0	—	—
2017	729.0	30	3.75
2018	800.0	36	4.50
2019	800.0	70	8.75

Source: compiled by the authors based on (Kolganova, 2018)

The dynamics of growth in the number of tires is still maintained at the present time, as can be seen from figure 4. Moreover, both tires produced in the country and imported tires are subject to recycling on the territory of the Russian Federation. At the same time, as can be seen from figure 5, the share of both tires is growing every year. Moreover, if the trends continue, by 2021 the number of tires imported and produced annually in the Russian Federation will increase by almost 2 times. This makes recycling even more necessary (Shmelev *et al.*, 2018).

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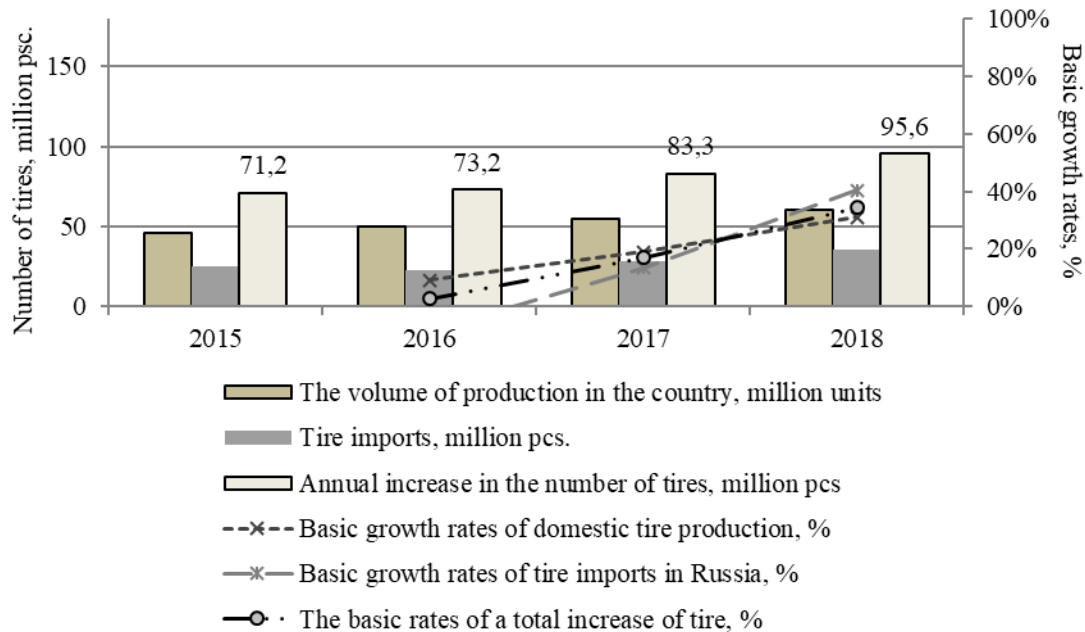


Fig. 4. Analysis of the dynamics of the increase in the number of tires on the territory of the Russian Federation

Source: compiled by the authors based on (Shmelev *et al.*, 2018)

One of the main reasons for the growth of tire production is the increase in the provision of individuals and legal entities with vehicles. Thus, according to the analytical Agency "AUTOSTAT" at the beginning of 2018, the provision of passenger cars in the Russian Federation on average amounted to 290 units per 1000 residents (Rostova *et al.*, 2019). This figure is twice the global average. However, it is significantly lower than the indicators of developed European countries. Almost every second Russian family has a private car, and every sixth has two or more of them.

Clearly, with an increase in the number of cars purchased, the number of tires purchased increases in direct proportion. At the same time, the climatic features of our country force us to purchase 2 types of rubber: for summer and winter time.

At the same time, in Russia, despite the state's policy to improve the environmental situation, citizens have formed an uncompromising attitude to secondary raw materials: for most Russians, this is just garbage, the recycling of which seems useless. In Russia, millions of old tires have accumulated, both in legal and illegal dumps. They are thrown along roadsides, on vacant lots, in courtyards, in forests, even used as fencing for flower beds (Grafkina, Mikhailov, Ivanov, 2009).

However, the transition to the concept of smart cities and the resulting increased attention to environmental issues have given rise to a number of legislative documents, including the decree of the Government of the Russian Federation dated December 28, 2017 No. 2971-R "on approval of standards for waste disposal from the use of goods for 2018-2020". In this document, the following standards for tire recycling were set for the group "Tires, tires and rubber chambers": 2018 – 20%, 2019 – 25%, 2020 – 30%.

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However, based on the analysis, it was revealed (table 6) that the plan approved in the decree about tire recycling was not fulfilled.

Table 6. Analysis of the implementation of the tire recycling plan

	Utilization		Planned percentage of utilization according to Decree, %	The percentage of the plan for recycling tires, %
	thousand tons	%		
2017	30	3.75	–	–
2018	36	4.50	20.0	22.5
2019	70	8.75	25.0	35.0

However, despite the fact that the standard for recycling tires in the Russian Federation has been increased by law, the situation still continues to be quite tense. Because the gap between standards and Western countries is significant – in Europe, this figure is approaching 80% (table 3).

Based on the analysis of the trend in the standard of tire recycling in Russia, if the rates set by the Government order are maintained, the Russian economy will be able to reach the average indicators of developed Western countries in 13 years, that is, by 2030.

3.4. Economic aspects of tire recycling in the Russian Federation

It is clear that the adoption of the law on mandatory tire recycling raises a number of issues related to the financing of this event.

To solve this issue, Russia, by analogy with the leading Western countries, has introduced a recycling fee. Moreover, this fee is imposed in general on the purchase of a car, as well as on tires.

At the same time, the recycling fee is understood as a one-time payment in favor of the state, which is used to take environmental safety measures and protect human life and health from harmful emissions during the operation of the vehicle.

Speaking about vehicle recycling in General, then the payment of the recycling fee is regulated by the Federal Law "About production and consumption waste". The law provides for mandatory payment of a recycling fee when purchasing a car.

The amount of the recycling fee required for payment when purchasing a vehicle is calculated by multiplying the base rate by the calculation factor.

Talking about the amount of the base rate present in the formula for calculating the recycling fee, it varies depending on the type of vehicle and is:

- ✓ for non-commercial passenger cars – 20,000 rubles;
- ✓ for commercial passenger cars, as well as trucks and buses – 150,000 rubles.

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The coefficient for calculating the amount depends on the year of manufacture of the car (other vehicle) and its parameters: size, weight, engine volume, and is regulated by the Decree of the Government of the Russian Federation No. 1291 of 26.12.2013.

The second direction is to receive a recycling fee from tire manufacturers. These companies are currently required to pay for recycling, as used car tires and cameras were included in the "list of types of production and consumption waste, which includes useful components, the disposal of which is prohibited" from January 1, 2019. The payment is different for the regions of the Russian Federation, so in Chelyabinsk they pay for the disposal of 1 ton of tires – 2000 rubles, in Krasnodar – 3500 rubles.

Recycling tires can be an important source of resource savings. So, if the weight of rubber is 70% of the weight of a worn tire (Afinogenov and et. al, 2016), then if the total volume of tires is processed, which in Russia is about 1 million tons per year (figure 4), you will get about 700,000 tons of rubber.

The saved raw materials can be used as raw materials for rubber products, construction materials, for example, can be used as road pavement.

At the same time, if you continue to burn worn tires, it is necessary to understand that 270 kilograms of soot and 450 kilograms of toxic waste will be released into the atmosphere (Afinogenov and et. al, 2016) per 1 ton of raw materials burned. If we assume that the entire volume of tires in Russia will be disposed of by incineration, then 270 million tons of soot and 450 million tons of gases will be released into the air.

These figures do not fit into the concept of smart cities. In this regard, the first place goes not only to the disposal of tire waste, but also to the use of environmentally friendly methods of their disposal.

4. Conclusions

According to the analysis of the international experience of urban development in accordance with the above concepts, one of the key areas of implementation of the concepts is the environmental aspect.

Almost all researchers agree on the need to resolve the issues related to waste disposal, which increases with the quality of life. Along with this, everyone notes the need to resolve issues with the growth of tire waste.

Despite the beginning of the implementation of sustainable development and smart city concepts, today Russian cities have much more significant issues than European ones. Based on the analysis, only about 20% of these wastes are currently disposed of, while in European countries this value is more than 80%. This discrepancy leads to the need to apply international experience in solving the problem of tire waste disposal in Russian cities.

For example, analyzing the European experience, experts say that the model of "manufacturer and importer Responsibility" for tire recycling, which is used in most European countries that were able to completely free their territories from the rubble of worn tires in 10-15 years, should be applied in our country.

There are several main reasons for the existing of problems with utilization of automobile tires in Russia, among them: the lack of a developed market for collecting tires, and the lack of a market for the sale of products for processing worn tires.

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At the same time, modern Russia is only developing in this area. Until recently, the state did not encourage the work of enterprises related to the handling of tires (collection, transportation, storage and processing). Car rubber processors were left to their own devices, as their activities were not regulated, and this type of activity is quite risky. But recently, a number of bills have been passed that have greatly improved the situation in this type of business. In addition, leasing companies are willing to work with equipment for recycling tires, which also has a positive effect on the activities of organizations.

Taking into account eco-friendly ways of recycling tire waste is becoming one of the important directions in the transition of Russian cities to the concept of Smart City".

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